

### REMARKS/ARGUMENTS

Claims 10-13 are pending in the Application. By this Amendment, claims 10-13 are being amended to improve their form. No new matter is involved.

In Paragraph 2 on page 2 of the Office Action, the Abstract of the Disclosure is objected to because it sets forth more than one paragraph. In response, Applicants are cancelling the Abstract in favor of the enclosed new Abstract which is the same but which sets forth the Abstract in a single paragraph. Therefore, the basis for objection to the Abstract has been removed.

In Paragraph 4 which begins on page 2 of the Office Action, claim 11 is rejected under 35 U.S.C. § 102(b) as anticipated by U.S. Patent 5,501,172 of Murai et al. In Paragraph 5 on page 3 of the Office Action, claim 13 is rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent 5,911,822 of Abe et al. In Paragraph 8 which begins on page 4 of the Office Action, claim 10 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Murai et al. and further in view of Wolf et al. (Silicon Processing Vol. 1). In Paragraph 9 which begins on page 6 of the Office Action, claim 12 is rejected under 35 U.S.C. § 103(a) as being unpatentable over Abe et al. and further in view of Wolf et al. These rejections are respectfully traversed, particularly in view of the amendments being made herein to claims 10-13.

As amended herein, claim 11 reads as follows:

"11. A method for producing a silicon single crystal by the Czochralski method, comprising the steps of using a silicon seed crystal which does not have a straight body portion but has a body shape selected from the group consisting of a cone shape, a pyramid shape, a cone shape whose side face is formed with a curved surface, a combined truncated cone and pyramid shape, and a combined

truncated pyramid and cone shape, bringing a tip end of the seed crystal into contact with a silicon melt to melt the tip end of the seed crystal, performing necking operation, and growing a silicon single crystal (emphasis added)".

Because the seed crystal having a shape as shown in FIGS. 3(a)-(c) and FIGS. 4(a)-(b) has a sharp-pointed tip end, it has an extremely small heat capacity at the tip end, thermal shock is attenuated when the seed crystal is brought into contact with the melt, and thus generation of slip dislocations is reduced. (See lines 16-26 of page 8 of the specification). In addition, because the seed crystal does not have a straight body portion, the volume of the seed crystal as a whole is significantly decreased, and thus unnecessary heat capacity is also decreased. As a result, the total heat capacity of the seed crystal and the seed crystal holder also becomes small, and the rate of temperature increase is increased when the seed crystal is approached to the melt surface. Moreover, the temperature gradient can be made smaller during its melting down and pulling after the tip end of the seed crystal is brought into contact with the melt. Therefore, dislocation becomes less likely to be generated, and already generated dislocations become more likely to disappear. (See line 27 of page 8 through line 19 of page 9; Table 3 on page 27; lines 10-24 of page 28, and elsewhere in the specification).

In Paragraph 4 which begins on page 2 of the Office Action, it is pointed out that in Fig. 1 of Murai, there is shown a tapered single crystalline silicon seed crystal used in the CZ method, the tapered seed length is denoted 'X' and the length of the neck is denoted 'Y', the tapered seed is seen as not having a straight body in Fig. 1, and so on. However, as described at lines 59-64 of column 3, lines 52-54 of column 5, and as shown in FIG. 1 and elsewhere in Murai, a seed crystal is used which has a shape of a prism or cylinder, that is, only a straight body portion, which

is completely different from a seed crystal not having a straight body portion as defined in claim 11 of the present application. Moreover, in Fig. 1 of Murai, the numeral 2 denotes a seed crystal, and a seed taper denoted by the numeral 3 ('X') and a cylindrical neck denoted by the numeral 5 ('Y') are formed following the lower end of the seed crystal 2 after dipping the seed crystal 2 into a silicon melt. (See lines 7-20 and 32-37 of column 4, and line 62 of column 5 to line 5 of column 6). Namely, the seed taper 3 and the cylindrical neck 5 are not a portion of the seed crystal. Thus, the seed crystal 2 of Murai has only a straight body portion, which is completely different from a seed crystal not having a straight body portion used in claim 11 of the present application.

Furthermore, the present application is a divisional application of U.S. 6,670,036 and the seed crystal as defined in claim 11 is being amended to have the same shape as that of seed crystal recited in claim 3 of U.S. Patent 6,670,036. Therefore, claim 11 as amended herein is submitted to clearly distinguish patentably over the prior art.

In Paragraph 5 of the Office Action, claim 13 is rejected as anticipated by the Abe et al. patent. However, claim 13 is being amended in a manner similar to claim 11. As amended, claim 13 reads as follows:

"13. A method for producing a silicon single crystal by the Czochralski method, comprising the steps of using a silicon seed crystal which does not have a straight body portion but has a body shape selected from the group consisting of a cone shape, a pyramid shape, a cone shape whose side face is formed with a curved surface, a combined truncated cone and pyramid shape, and a combined truncated pyramid and cone shape, bringing a tip end of the seed crystal into contact with a silicon melt to melt the tip end of the seed

crystal, and growing a silicon single crystal without performing necking operation (emphasis added)."

By using a seed crystal as defined in claim 13 as amended, dislocations are less likely to be generated, and already generated dislocations are likely to disappear, as discussed above. In addition, by growing a silicon single crystal without performing a necking operation, it is possible to realize growth of single crystals having a large diameter and weight. (See lines 2-13 of page 32 of the specification).

In Paragraph 5 of the Office Action, it is pointed out that Abe et al. describes in claim 1 thereof a Si seed used to grow a Si single crystal without performing the necking operation, the seed crystal has a sharp pointed shape or a truncation of such a shape, and such a shape does not have a straight body (see Figs. 2A-2D), and so on. However, as is clear from Figs. 2A-2D and lines 6-27 of column 9 of the reference, only the tip end of the seed crystal of Abe has a conical portion 7 or a pyramidal portion 8, and a portion other than the tip end is a straight body portion. (See lines 22-23 of column 9). Namely, the seed crystal of Abe has a straight body portion, which is completely different from a seed crystal not having a straight body portion used in claim 13 of the present application. Furthermore, a seed crystal used in the method of claim 13 of the present application as amended, has the same shape as that of the seed crystal recited in claim 3 of U.S. Patent 6,670,036 lending further support to the patentability of claim 13.

In Paragraph 8 of the Office Action, Claim 10 is rejected as unpatentable over Murai et al. and further in view of Wolf et al. As amended herein, claim 10 reads as follows:

"10. A method for producing a silicon single crystal by the Czochralski method, comprising the steps of using a silicon seed

crystal wherein oxygen concentration in the seed crystal is 12ppma (JEIDA) or less, bringing a tip end of the seed crystal into contact with a silicon melt to melt the tip end of the seed crystal, performing necking operation, and growing a silicon single crystal (emphasis added)".

The principal feature of the method of claim 10 is that of using a silicon seed crystal wherein oxygen concentration in the seed crystal is 12 ppma (JEIDA) or less. As described at lines 5-15 of page 8 and elsewhere in the specification, if such a seed crystal having a lower concentration of oxygen is used, oxygen does not precipitate during, for example, contact with the melt and melting down therein of the seed crystal, and substantially no slip dislocation containing precipitated oxygen as a nucleus is generated. Therefore, the rate of success in making crystals which are dislocation-free is improved, regardless of the use of necking, and thereby productivity and production yield of dislocation-free silicon single crystals are improved. In particular, in the cases of using a seed crystal having an oxygen concentration of 12 ppma (JEIDA) or less as set forth in amended claim 10, the dislocation-free rate is still higher, as seen in Table 1 on page 20 of the specification.

On page 5 of the Office Action, it is pointed out that the typical oxygen concentration is found on page 59 of Wolf et al. to be from 10-20 ppma, the beneficial strengthening effect of oxygen is disclosed on page 61, and so on, and it is further asserted that it would have been obvious to one of skill in the art at the time the present invention was made to combine Murai et al. and Wolf et al., because Wolf et al. describes ways of strengthening Si and Murai et al. suggests the need for stronger Si at the narrow neck formed from the seed during CZ pulling.

Wolf et al. teaches, in the first paragraph on page 59 thereof, that oxygen concentrations in CZ Si crystals typically range from 10 to 20 ppma. In the third

paragraph on that page, it is taught that oxygen is incorporated as a result of crucible erosion during CZ growth, and in general, higher concentrations of oxygen are founded at the seed end of the ingot because more crucible wall area is in contact with the melt when the crucible is full. Namely, Wolf et al. only teaches oxygen concentrations in a silicon single crystal ingot grown by the CZ method, but neither teaches nor suggests oxygen concentration in a seed crystal used in the CZ method. Moreover, page 61 thereof only teaches oxygen precipitation in a wafer produced by slicing a silicon single crystal.

As mentioned above, Murai discloses a method of growing silicon single crystals, comprising the steps of using a seed crystal with a shape of prism or cylinder, forming a long seed taper at the lower end of the seed crystal, and so forth, as shown in FIG. 1, as set forth in claim 1, and elsewhere therein. However, Murai neither teaches nor suggests oxygen concentration in the seed crystal.

Namely, in Murai and Wolf, there is no motivation to use a seed crystal having an oxygen concentration of 12 ppma or less as in the case of claim 10 of the present application. Therefore, if Murai and Wolf are combined, the resulting combination may lead to controlling oxygen concentration in a growing silicon single crystal or oxygen precipitation in a wafer, but does not lead to using a seed crystal with an oxygen concentration of 12 ppma or less. Accordingly, even a person skilled in the art could not derive from Murai and Wolf the invention as defined in claim 10 which includes using a seed crystal having an oxygen concentration of 12 ppma or less.

Moreover, oxygen concentration in a seed crystal as used in the method of claim 10 is similar to that in the case of the seed crystal recited in claim 1 of U.S. Patent 6,670,036. Namely, it is clear that amended claim 10 herein in which a single crystal is grown using such seed crystal, is patentable.

In Paragraph 9 of the Office Action, claim 12 is rejected as being unpatentable over Abe et al. and further in view of Wolf et al. As amended herein, claim 12 reads as follows:

“12. A method for producing a silicon single crystal by the Czochralski method, comprising the steps of using a silicon seed crystal wherein oxygen concentration in the seed crystal is 12ppma (JEIDA) or less, bringing a tip end of the seed crystal into contact with a silicon melt to melt the tip end of the seed crystal, and growing a silicon single crystal without performing necking operation (emphasis added)”.

And, if such a silicon seed crystal having an oxygen concentration of 12 ppma (JEIDA) or less is used, generation of slip dislocations is reduced as mentioned above. In addition, it is possible to particularly realize growth of single crystals having a large diameter and weight because necking operation is not performed.

Abe teaches a method of using a seed crystal with a sharp-pointed tip end and growing a single crystal without performing necking operation in claim 1, Figs. 2A-2D and so on, but neither teaches nor suggests oxygen concentration in the seed crystal. On the other hand, Wolf et al. only teaches that oxygen concentrations in a silicon single crystal grown by the CZ method typically range from 10 to 20 as mentioned above, but neither reference teaches nor suggests oxygen concentration in the seed crystal.

Namely, in Abe and Wolf, there is no motivation to use a seed crystal having an oxygen concentration of 12 ppma or less, as in the case of claim 12. Therefore, even if Abe and Wolf are combined, claim 12 is still patentably distinct thereover.

Furthermore, oxygen concentration in a seed crystal as used in claim 12 is like that of a seed crystal recited in claim 1 of U.S. Patent 6,670,036.

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For the reasons set forth above, claims 10-13 as amended herein are submitted to clearly distinguish patentably over the cited art. Therefore, reconsideration and allowance are respectfully requested.

If for any reason the Examiner finds the application other than in condition for allowance, the Examiner is requested to call the undersigned attorney at the Los Angeles, California telephone number (213) 337-6846 to discuss the steps necessary for placing the application in condition for allowance.

If there are any fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1314.

Respectfully submitted,  
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